COMPARATIVE ANALYSIS OF MANDIBULAR AND MID-FACE FRACTURES IN MISSILE AND BLUNT TRAUMA: 4,015 CASES

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Although most reports on facial fractures have been limited to fractures of the mandible due to blunt trauma, some studies[1-10] have been concerned with fractures of the middle third of the facial skeleton. In the last century, Le Forte[1] described fractures of the zygomatico-maxillary complex and the detachment of facial bones from the facial skeleton along particular planes of cleavage. More recently, Rowe and Killey[2] established a series of comparison tables using the Le Forte classifications of facial fractures. Their studies, particularly when supplemented with data of other investigators,[3-10] stand as the most comprehensive review on facial fractures due to blunt trauma.

The ratio of mandibular fractures to mid-face fractures due to blunt trauma historically has been considered to be 2 to 1; however, a rise in the incidence of mid-face fractures has been noted in recent reports on both civilian and military patients.[11]

It is conjectured that the rise in mid-face fractures in military patients is related to the high deployment of sophisticated weapons in present day combat activities. The technological advancements of these weapons have resulted in greater diversity and magnitude of trauma than previously experienced.[12] This investigation is confined to the analysis of data on facial fractures subsequent to some of these forms of trauma.

The purpose of this study was to compare the relative occurrence of mandibular, mid-face, and combination fractures of the mandible and mid-face due to various types of trauma which have afflicted members of the U.S. Army. An additional purpose of this study was to formulate a basis for comparatively evaluating facial injuries caused by diverse forms of missile and blunt trauma.

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MATERIALS and METHODS

This study was based on data obtained in a survey of oral and maxillofacial injuries at selected U.S. Army hospitals in Vietnam during a two-year period ending 30 June 1969, and at selected military installations in the continental United States, Berlin, and Hawaii during a one-year period ending 30 June 1968. Data were obtained from reports submitted by attending Army dentists. Most of the patients who were reported to have suffered facial bone fractures were active duty U.S. Army personnel.

Accumulated data concerning patients with facial fractures were divided into four general categories of trauma and arbitrarily placed in a convenient order: (1) bullet trauma, (2) missile fragment trauma, (3) "non-ballistic" missile trauma, and (4) blunt trauma. "Non-ballistic" missiles included rocks, gravel, glass, falling debris, and hurled objects. The order selected for blunt trauma injuries was: vehicular accidents, miscellaneous accidents, sports accidents, and altercations.

The specific facial bones investigated in these trauma categories were the mandible, maxilla, malar, and nasal bones. The zygomatic arch and the floor of the orbit were also included as separate entities. The mandibular fractures were further characterized as those with evidence of comminution and those with evidence of avulsion.

Each trauma category was analyzed with electronic data processing equipment for the incidence of single and concomitant facial bone fracture cases, plus the incidence of specific facial bones fractured in concomitant cases. From this data the following information was assembled: (1) fractures of the mandible only, (2) fractures exclusive to one or more mid-face bones, and (3) combination fractures of the mandible and one or more mid-face bones.

In order to better relate to the literature on facial fractures, the mandibular, mid-face, and combination fractures were expressed in ratio form. This was accomplished by selecting mandibular fractures as the reference point from which comparisons would be made (mandibular fractures were assigned the value of one). The values for mid-face and combination fractures were adjusted accordingly. This procedure was also carried out on data reported in previous studies by Rowe and Killey[2] and Schuchardt et al.[3]

RESULTS

A total of 4,015 facial fracture patients were included in this study, of which 67.4 percent (2,705) were injured by missiles and 32.6 percent (1,310) were injured by blunt trauma.

In the missile group: 23.6 percent (638) of the individuals were injured by bullets, 45.4 percent (1,228) were injured by missile fragments, and 31.0 percent (839) were injured by "non-ballistic" missiles. All of the bullet and fragment injuries and about one-quarter of the "non-ballistic" missile injuries were sustained under combat circumstances.

In the blunt trauma group: 35.3 percent (464) were associated with vehicular accidents, 16.2 percent (213) were involved in miscellaneous accidents, 5.1 percent (67) were sports-related accidents, and 43.6 percent (573) of the blunt trauma fractures were caused by altercations. About half of the vehicular accidents and about half of the miscellaneous accidents were sustained under combat circumstances.

Table I reveals the four general categories of trauma and the sub-categories of blunt trauma arranged in order of their respective single and concomitant facial bone fracture incidences. Table II shows the specific facial bones involved in those cases where only one bone was fractured. In all categories of trauma where only one facial bone was fractured, the mandible was most frequently involved. The nasal bone ranked second in frequency of specific bones fractured. The individual facial bones intimately associated with the zygomatico-maxillary complex (malar, zygomatic arch, and orbital floor) infrequently occurred as single facial bone fractures. The greater part of the maxilla is anatomically less intimately associated with the complex. Hence, a moderate incidence of maxillary fractures alone was observed. Table III shows the concomitant fracture cases, and enumerates the specific facial bones which were fractured. In general, the bones of the zygomatico-maxillary complex had the highest incidences of fractures in the concomitant fracture cases. Table IV revealed that mandibular comminution and mandibular avulsion were generally more common in combination fractures than in mandibular fractures alone. These tables served as the basis for the following observations:

Bullet trauma:

Bullet wounds had the lowest incidence of single bone fracture cases (see Table I) mainly because of the infrequent occurrences of nasal bone fractures alone or single fractures of the bones of the zygomatico-maxillary complex (see Table II). Although mandibular fractures alone were relatively common, the infrequence of solitary fractures of mid-facial bones accounted for the low incidence of exclusive mid-face fractures (see Table V) and the low ratio of mid-face fractures to mandibular fractures (see Table VI) in this group.

However, bullet wounds had the highest incidence of concomitant facial fracture cases (see Table I) with correspondingly high rates of specific facial bone fractures (see Table III). Moreover, the high incidence of mandibular fractures in those cases

with concomitant fractures (see Tables III and V) is sufficient to effect a comparatively high ratio of combination fractures when compared to the solitary mandibular fractures (see Table VI).

Mandibular comminution and mandibular avulsion were most often noted in bullet trauma. They occurred eight percent more frequent when the mandible was fractured alone than when fractured in combination with mid-face bones. In each fracture group, mandibular comminution was approximately 25 percent more common than mandibular avulsion (see Table IV).

Fragment trauma:

Although concomitant fracture cases were less frequent (see Table I) and the rates of specific bones fractured in these cases were less for fragment trauma than for bullet trauma (see Table III), a higher percentage of exclusive mid-face fractures was recorded for fragment trauma (see Table V). This was due to the relatively high number of solitary fractures of the maxilla or nasal bones (see Table II) plus the relatively low number of solitary or concomitant mandibular fractures (see Table III). The net effect was that exclusive mid-face fractures subsequent to fragment wounds were 16.5 percent more common than mandibular fractures alone (see Table V). Although lower in value than in bullet trauma, the incidence of mandibular comminution due to missile fragments was about equal in mandibular fractures alone and combination fractures. In each fracture group, mandibular comminution was approximately 30 percent more common than mandibular avulsion (see Table IV).

"Non-ballistic" missile trauma:

In contrast to bullet and fragment trauma, "non-ballistic" missile trauma was rarely associated with tissue penetration. The incidence of single facial bone fractures due to "non-ballistic" missiles was closer numerically to blunt trauma than it was to penetrating types of missiles (see Table I). Although the highest percentage of nasal fractures alone were recorded in "non-ballistic" missile wounds, the rates of other facial bone fractures either as single or concomitant fractures were relatively low (see Tables II and III). In addition, this high frequency of nasal fractures was primarily responsible for a 17 percent higher rate of exclusive mid-face fractures than solitary mandibular fractures in this group (see Table V).

In combination fractures due to "non-ballistic" missiles, the incidence of mandibular comminution was more than twice and the incidence of mandibular avulsion was more than five times the respective values computed for mandibular fractures alone (see Table IV).

Blunt trauma:

Analysis of the sub-categories of blunt trauma revealed that vehicular accidents had the lowest incidence of single facial

bones fractured concomitantly (see Table III). The relatively low frequency of nasal fractures alone (see Table II) was largely responsible for the relatively low incidence of exclusive mid-face fractures in vehicular accidents. The incidence of combination fractures (see Table V) was high enough to make the ratio of these fractures to that of mandibular fractures alone greater in vehicular accidents than in any other form of trauma (see Table VI).

The frequent occurrence of mandibular or nasal fractures only in miscellaneous and sports accidents (see Table II) accounts for these types of trauma having higher incidences of single facial bone fractures than did vehicular accidents (see Table I). In addition, the incidence of concomitant fractures in these accidents was much lower than in vehicular accidents. Furthermore neither the mandible nor the nasal bones were involved in concomitant fractures due to sports accidents (see Table III). Sports accidents were clearly either a mandibular or a mid-facial bone fracture exclusively (see Table V).

The highest incidence of single facial bone fractures was found in altercations (see Table I). The lower jaw and the nose were such specific targets that over 81 percent of the altercations which resulted in facial fractures had a fracture of either the mandible alone or the nasal bones alone (see Table II). The few concomitant fractures which resulted from altercations rarely included the mandible or nasal bones (see Table III).

Mandibular comminution due to blunt trauma was approximately twice as frequent in combination fractures as in mandibular fractures alone; yet lower than in the other major categories of trauma. Mandibular avulsion occurred in about 10 percent of the combination fracture patients but rarely occurred in solitary mandibular fractures (see Table IV).

DISCUSSION

The current literature on facial fractures does not afford sufficient data for valid comparisons of facial fractures caused by diverse forms of trauma. The literature, predominately, has been more concerned with mandibular fractures than mid-face fractures, treatment more than cause, and blunt trauma more than the other forms of trauma.

Although most of the data used for this study were related to patients who received facial fractures in combat situations, approximately one-third of the data sample involved persons acquiring facial fractures in situations (vehicular accidents, altercations, sports accidents, etc.) comparable to those commonly occurring in the civilian community.

Missile trauma:

In contrast to blunt trauma, missile impact sites on the face are more random in distribution. It is conjectured that if data were compiled for a significant number of cases (including those which were fatal), this distribution would be uniform over the surface area. This study was based on the premise that, in non-fatal cases, the incidence of mid-face fractures would be lower in the more lethal forms of missile trauma, and that the relative distribution of mandibular, mid-face, and combination fractures would reveal a pattern based on the relative potency of various forms of missiles.

The comparatively low incidence of exclusive mid-face fractures (34.3 percent) due to bullets suggests that only persons receiving a tangential hit to the mid-face would survive. The high incidence of combination fractures (20.6 percent), where the trajectory of the bullet aligns with the mandible and mid-face, strengthens this supposition.

The 18.6 percent higher incidence of mid-face fractures due to fragments suggests that individuals are more able to survive direct hits to the mid-face by fragments than by bullets. This is due in fact to the penetration depth of missile fragments being less than that of bullets, due to the lower momentum and higher retardation of the fragments. In addition, the irregular configurations of fragments cause a more rapid retardation of momentum upon penetration into the facial tissues and thus a more rapid release of expended energy nearer the surface than occurs with bullet wounds. This is extremely important in the mid-face area where further penetration and deeper release of energy would seriously affect vital structures.

In combat situations, explosions will frequently "shower" individuals in the immediate area with rocks, gravel, glass, falling debris, and other secondary missiles. These "non-ballistic" missiles (including hurled objects) have lower velocities, momenta, and energy levels than either bullets or missile fragments. Therefore, these missiles cause a relatively higher incidence of non-fatal mid-face fractures than bullets because of their lower potency. Although missile fragments and "non-ballistic" missiles each had 17 percent more mid-face fractures than mandibular fractures alone, the comparatively low incidence of combination fractures by "non-ballistic" missiles is attributed to the less severe type of forces involved in this class of trauma.

Unlike bullet trauma, the relatively low incidence of mandibular fractures subsequent to missile fragment and "non-ballistic" missile trauma suggests that these insults are often of insufficient magnitude to cause mandibular fractures, but still are of sufficient force to create fractures of the mid-face. The comparatively low incidence of combination fractures due to fragment and "non-ballistic" missiles indicates the relatively low magnitude

of these trauma as compared to that of bullets.

Higher incidences of mandibular comminution and mandibular avulsion were recorded for penetrating missiles (bullets and missile fragments) when the mandible was fractured alone rather than in combination with mid-facial bones. The contrast was greatest in bullet trauma and was related to the consistently high level of kinetic energy associated with this type of trauma. In bullet trauma, when this level of energy was confined to mandibular fractures alone, a higher degree of comminution and avulsion was recorded than when the energy was dissipated by the fracturing of additional facial bones.

The highly variable masses and velocities associated with "non-ballistic" missiles gave "non-ballistic" missile trauma the widest range of insulting magnitude. It is presumed that combination fractures were caused by the more severe levels of energy which in effect developed higher incidences of mandibular comminution and mandibular avulsion.

Blunt trauma:

Although the mandible encompasses less surface area than the more fragile mid-face skeleton, its higher incidence of fracture subsequent to blunt trauma insults is considered to be due to its exposed position and the direction from which blunt trauma blows commonly strike the face. In this population sample, a number of blunt trauma injuries were the result of altercations. The traditional target in such situations is most often the mandible.

The relative incidence of mid-face fractures is appreciably higher than that reported in previous studies by Rowe and Killey[2] and Schuchardt et al.[3] This is consistent with Dingman's contention[11] that a rise in the incidence of mid-face fractures becomes apparent when military reporting and high-speed transportation accident cases are considered. Although a specific comparison cannot be made because of the diversity of accidents and circumstances between studies, in contrast to the combined data of these investigators,[2,3] exclusive mid-face fractures subsequent to blunt trauma were found to be 14 percent higher and combination fractures were 4 percent higher; mandibular fractures occurred 22 percent less frequently. These variations are considered to be due to the more aggressive activities characterizing a military population; the magnitude of blunt trauma forces is considered to be higher. As Rowe and Killey[2] contend, blunt trauma forces of higher magnitude effect a relative increase in the incidence of mid-face fractures when compared to mandibular fractures.

SUMMARY

Data pertaining to 4,015 facial fracture cases due to various types of trauma were examined to determine the relative incidence of: mandibular fractures alone, exclusive fractures of one or more mid-face bones, and combination fractures of the mandible and one or more mid-face bones for each form of trauma. These findings were expressed in ratio form. On analysis the following observations were made:

1. In bullet trauma: 45.1 percent of the patients had mandibular fractures alone, 34.3 percent had exclusive mid-face fractures, and 20.6 percent had combination fractures of the mandible and one or more mid-face bones. Expressed as a ratio, with mandibular fractures alone assigned a value of one, these values became 1 to 0.760 to 0.454 for bullet trauma.

2. In fragment trauma: 36.4 percent of the patients had mandibular fractures, 52.9 percent had exclusive mid-face fractures, and 10.7 percent had combination fractures. Expressed as a ratio, these values became 1 to 1.454 to 0.293 for missile fragment trauma.

3. In "non-ballistic" missile trauma: 37.9 percent of the patients had mandibular fractures, 55.7 percent had exclusive mid-face fractures, and 6.4 percent had combination fractures. Expressed as a ratio, these values became 1 to 1.437 to 0.201 for "non-ballistic" missile trauma.

4. In blunt trauma: 48.0 percent of the patients had mandibular fractures alone, 43.6 percent had exclusive mid-face fractures, and 8.4 percent had combination fractures of the mandible and one or more mid-face bones. Expressed as a ratio, these values became 1 to 0.908 to 0.175 for blunt trauma.

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TABLE I

INCIDENCE* OF SINGLE AND CONCOMITANT FACIAL BONE FRACTURES

Cause of Injury	Single Facial Bone Fractures	Concomitant Facial Bone Fracture Cases
Bullets	353 (55.3)	285 (44.7)
Fragments	753 (61.3)	475 (38.7)
"Non-ballistic" missiles	618 (73.7)	221 (26.3)
Blunt trauma:	988 (75.4)	322 (24.6)
Vehicular accidents	274 (59.3)	188 (40.7)
Miscellaneous accidents	162 (77.9)	46 (22.1)
Sports accidents	54 (80.6)	13 (19.4)
Altercations	498 (86.9)	75 (13.1)
All forms of trauma	2,712 (67.5)	1,303 (32.5)

* Numbers in parenthesis are percentages calculated on the basis of the total number of patients in each trauma category.

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TABLE II

INCIDENCE* OF SPECIFIC SINGLE FACIAL BONE FRACTURES

Cause of Injury	Mandible	Nasal	Maxilla	Malar	Zygomatic Arch	Orbital Floor
Bullets	288 (45.1)	10 (1.6)	30 (4.7)	2 (0.3)	20 (3.1)	3 (0.5)
Fragments	447 (36.4)	95 (7.7)	165 (13.4)	27 (2.2)	none	19 (1.5)
"Non-ballistic" missiles	318 (37.9)	242 (28.8)	34 (4.1)	8 (1.0)	13 (1.5)	3 (0.4)
Blunt trauma:	629 (48.0)	239 (18.2)	71 (5.4)	21 (1.6)	21 (1.6)	7 (0.5)
Vehicular accidents	175 (37.9)	43 (9.3)	34 (7.4)	14 (3.0)	6 (1.3)	2 (0.4)
Miscellaneous accidents	100 (48.1)	41 (19.7)	14 (6.7)	1 (0.5)	4 (1.9)	2 (1.0)
Sports accidents	28 (42.0)	15 (22.4)	6 (9.0)	2 (3.0)	3 (4.5)	none
Altercations	326 (56.9)	140 (24.4)	17 (3.0)	4 (0.7)	8 (1.4)	3 (0.5)
All forms of trauma	1,682 (41.9)	586 (14.6)	300 (7.5)	58 (1.4)	54 (1.3)	32 (0.8)

* Numbers in parenthesis are percentages calculated on the basis of the total number of patients in each trauma category.

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TABLE III

INCIDENCE* OF SPECIFIC FACIAL BONES FRACTURED CONCOMITANTLY

Cause of Injury	Mandible	Nasal	Maxilla	Malar	Zygomatic Arch	Orbital Floor
Bullets	131 (20.5)	123 (19.3)	250 (39.2)	188 (29.5)	122 (19.1)	159 (24.9)
Fragments	131 (10.7)	162 (13.2)	402 (32.7)	297 (24.2)	190 (15.5)	232 (18.9)
"Non-ballistic" missiles	64 (7.6)	73 (8.7)	175 (20.8)	166 (19.8)	127 (15.1)	134 (16.0)
Blunt trauma:	110 (8.4)	115 (8.8)	235 (17.9)	252 (19.2)	204 (15.6)	210 (16.0)
Vehicular accidents	86 (18.6)	92 (19.9)	153 (33.1)	140 (30.3)	112 (24.2)	120 (26.0)
Misc accidents	8 (3.3)	12 (5.8)	28 (13.5)	38 (18.3)	25 (12.0)	33 (15.9)
Sports accidents	none	none	8 (11.9)	10 (14.9)	9 (13.4)	9 (13.4)
Altercations	16 (2.8)	11 (1.9)	46 (8.0)	64 (11.2)	58 (10.1)	48 (8.4)
All forms of trauma	436 (10.9)	473 (11.8)	1,062 (26.5)	903 (22.5)	643 (16.0)	735 (18.3)

* Numbers in parenthesis are percentages calculated on the basis of the total number of patients in each trauma category.

TABLE IV

INCIDENCE* OF COMMINUTION AND AVULSION IN MANDIBULAR FRACTURES

Cause of Injury	Mandibular Fractures Alone		Combination Fractures	
	Comminuted	Avulsed	Comminuted	Avulsed
Bullets	260 (90.3)	188 (65.3)	108 (82.4)	74 (56.5)
Fragments	323 (72.3)	190 (42.5)	93 (71.0)	56 (42.7)
"Non-ballistic" missiles	66 (20.8)	16 (5.0)	36 (56.3)	16 (25.0)
Blunt trauma:	158 (25.1)	6 (1.0)	55 (50.0)	12 (10.9)
Vehicular accidents	58 (33.1)	6 (3.4)	47 (54.7)	8 (9.3)
Miscellaneous accidents	25 (25.0)	none	4 (50.0)	2 (25.0)
Sports accidents	5 (17.9)	none	none	none
Altercations	70 (21.5)	none	4 (25.0)	2 (12.5)
All forms of trauma	807 (48.0)	400 (23.8)	292 (67.0)	158 (36.2)

* Based on the number of mandibular fractures alone and concomitant mandibular fractures in each trauma category.

TABLE V

INCIDENCE* OF FACIAL BONES FRACTURED BY VARIOUS CAUSES

Cause of Injury	Mandibular	Mid-Face	Combination
Bullets	288 (45.1)	219 (34.3)	131 (20.5)
Fragments	447 (36.4)	650 (52.9)	131 (10.7)
"Non-ballistic" missiles	318 (37.9)	457 (54.5)	64 (7.6)
Blunt trauma:	629 (48.0)	571 (43.6)	110 (8.4)
Vehicular accidents	175 (37.9)	201 (43.5)	86 (18.6)
Miscellaneous accidents	100 (48.1)	100 (48.1)	8 (3.8)
Sports accidents	28 (42.0)	39 (58.2)	none
Altercations	326 (56.9)	231 (40.3)	16 (2.8)
All forms of trauma	1,682 (41.9)	1,897 (47.2)	436 (10.9)
Previous study, year:			
Rowe and Killey, 1955	336 (67.2)	118 (23.6)	46 (9.2)
Rowe and Killey, 1965	535 (53.5)	383 (38.2)	82 (8.2)
Schuchardt et al, 1961	1,174 (75.0)	324 (20.7)	68 (4.3)
Schuchardt et al, 1966	773 (59.0)	450 (34.3)	88 (6.7)
Previous studies combined	2,818 (64.4)	1,275 (29.1)	284 (6.5)

* Numbers in parenthesis are percentages calculated on the basis of the total number of patients in each trauma category.

TABLE VI

ADJUSTED RATIOS OF FRACTURE INCIDENCES

Cause of Injury	Mandibular	Mid-Face	Combination
Bullets	1	0.760	0.455
Fragments	1	1.454	0.293
"Non-ballistic" missiles	1	1.437	0.201
Blunt trauma:	1	0.908	0.175
Vehicular accidents	1	1.149	0.491
Miscellaneous accidents	1	1.000	0.080
Sports accidents	1	1.393	0.000
Altercations	1	0.709	0.049
All forms of trauma	1	1.128	0.259
Previous study, year:			
Rowe and Killey, 1955	1	0.351	0.137
Rowe and Killey, 1965	1	0.716	0.153
Schuchardt et al, 1961	1	0.276	0.058
Schuchardt et al, 1966	1	0.582	0.114
Above studies combined	1	0.452	0.101